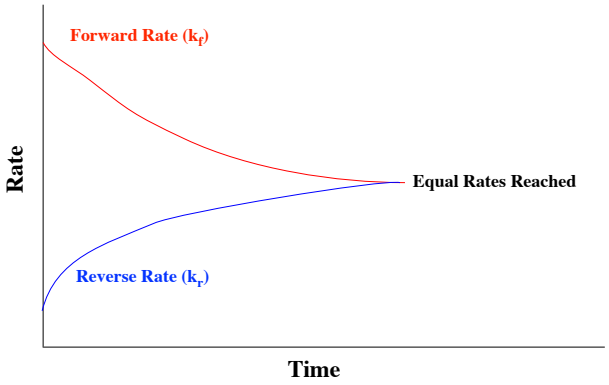
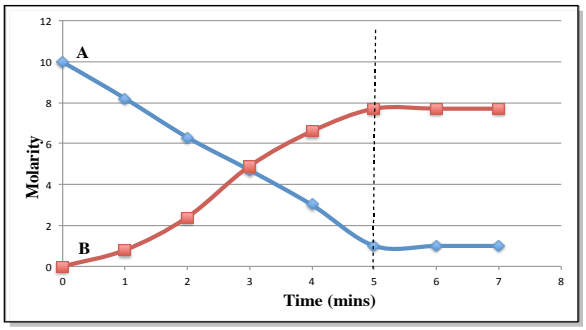
CONCEPT: THE EQUILIBRIUM STATE

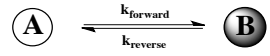
Most chemical reactions do not go to ***completion***.

- _____ do not completely convert into _____ and reactant concentrations do not go down to _____.
- These reactions reach ***chemical equilibrium***, in which the reaction moves in the forward and reverse direction.

$$K = \frac{k_{forward}}{k_{reverse}} = \frac{products}{reactants}$$

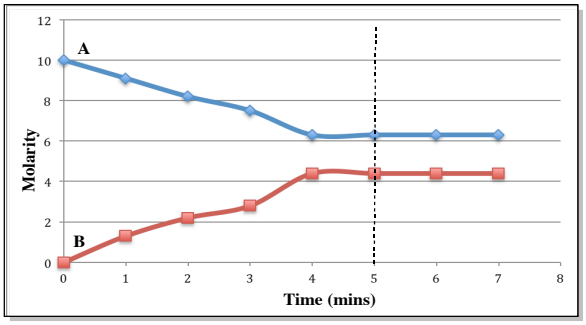


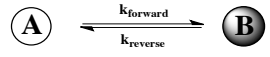




$$K = \frac{products}{reactants} = \frac{B}{A} =$$

• K is _____ than 1 so the _____ direction and _____ are favored.





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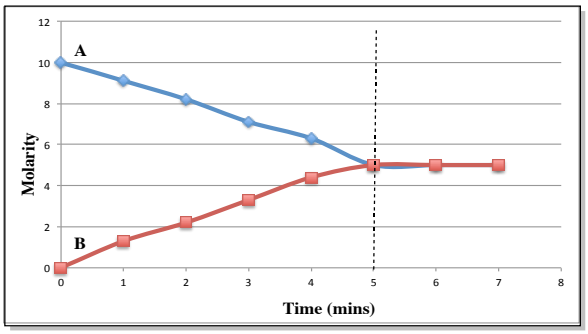

$$K = \frac{products}{reactants} = \frac{B}{A} =$$

• K is _____ than 1 so _____ direction and _____ are favored.

PRACTICE: THE EQUILIBRIUM STATE CALCULATIONS 1

EXAMPLE 1: For the following chemical reaction $N_2\,(g) + O_2\,(g) \rightleftharpoons 2\,NO\,(g)$, $K_c = 3.7 \times 10^{-5}$, $k_f = 2.5 \times 10^{-3}$ and $k_r = 67.57$. Addition of a catalyst increases the forward rate constant 1.8×10^{-1}. What is the new reverse rate constant after the addition of the catalyst?

EXAMPLE 2: Consider the following reactions at 25°C:

Reaction	Kc
$2\,NO\,(g) \rightleftharpoons N_2\,(g) + O_2\,(g)$	1×10^{30}
$2\,H_2O\,(g) \rightleftharpoons 2\,H_2\,(g) + O_2\,(g)$	5×10^{-82}
$2\,CO\,(g) + O_2\,(g) \rightleftharpoons 2\,CO_2\,(g)$	3×10^{91}

Which compound is most likely to dissociate and give $O_2\,(g)$ at 25°C?

a) CO_2 b) NO c) CO d) H_2O

PRACTICE: Write the equilibrium expression for the following reaction.

$$4\,NH_3\,(g) + 3\,O_2\,(g) \rightleftharpoons 2\,N_2\,(g) + 6\,H_2O\,(l)$$

PRACTICE: THE EQUILIBRIUM STATE CALCULATIONS 2

EXAMPLE 1: When reaction 1 and 2 below are added together, the result is reaction 3.

1) $H_2O\,(l) + HNO_2\,(aq) \rightleftharpoons H_3O^+\,(aq) + NO_2^-\,(aq)$ $\quad K_1 = 4.50 \times 10^{-4}$

2) $H_3O^+\,(aq) + OH^-\,(aq) \rightleftharpoons 2\,H_2O\,(l)$ $\quad K_2 = 1.00 \times 10^{14}$

3) $HNO_2\,(aq) + OH^-\,(aq) \rightleftharpoons NO_2^-\,(aq) + H_2O\,(l)$ $\quad K_3 = ?$

Find the equilibrium constant, K_3.

A) 4.50×10^{-18} B) 2.22×10^{17} C) 4.50×10^{10} D) 1.00×10^{14}

EXAMPLE 2: What is the equilibrium constant for the reaction

$NH_3(aq) + H_3O^+\,(aq) \rightleftharpoons NH_4^+\,(aq) + H_2O(l)$

Given the following information

$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ $\quad K_c = 1.8\text{x}10^{-5}$

$4H_2O(l) \rightleftharpoons 2OH^-(aq) + 2H_3O^+(aq)$ $\quad K_c = 1\text{x}10^{-28}$

a) $1.8\text{x}10^{9}$ b) $4.5\text{x}10^{7}$ c) $9.0\text{x}10^{10}$ d) $1.8\text{x}10^{-5}$ e) $2.7\text{x}10^{6}$